in air using a 10 zone belt Lindberg furnace with a cycle time of 30 minutes and a peak temperature of 850°C for 10 minutes. After the electrodes were fired onto the substrate a dielectric (DuPont *i*Technologies, product #5704) pattern, shown in Figure 2, was screen printed over the electrodes with a screen (Microcircuit Engineering Corporation), having an emulsion thickness of 0.9 mil. The parts were then dried at 120°C for 10 minutes and fired using the same firing cycle as described above.

B. Semiconducting Metal Oxide Preparation and Application on the Array Chip

Approximately 175 mg of the semiconducting metal oxide powder or the mixture of a semiconducting metal oxide with a suitable glass frit (DuPont *i*Technologies product #F2889 or F3876) or the mixture of the semiconducting metal oxide powder with other inorganic compounds was weighed out on to a glass slide with approximately 75 mg of a suitable medium (DuPont *i*Technologies product #M2619) and 1 mg of a suitable surfactant (DuPont *i*Technologies product #R0546). The medium and surfactant were mixed together and the metal oxide powder or mixture was added to the medium and surfactant gradually to ensure wetting. If needed, a suitable solvent (DuPont *i*Technologies product #R4553) was added at this time to reduce the viscosity. The paste was then transferred to an agate mortar and pestle for more thorough mixing. Using a finely pointed wooden applicator, a very small amount of paste was then placed into one of the wells of the array chip. This procedure was repeated with each of the metal oxide powders or mixtures until all of the wells on the array chip were filled. Once the wells on the array chip were filled with pastes, the array chip was allowed to sit in a closed chamber with a low flow of $N_2$ gas passing over the chip. The array chip was then dried at 120°C for 10 minutes. Firing was done in air using a Fisher programmable box furnace with a

1°C/minute ramp rate up to 650°C, where it was held at temperature for 30 minutes. The cooling rate was 5°C/minute to room temperature.

C. Wiring of the Array Chip

Lead wires were fabricated using approximately 1.5" of 0.005" platinum wire. One end of the wire was bare and the other end was connected to a female RS232 connector. The bare end of a platinum lead wire was attached to one of the open conductor pads on the array chip using a conducting paste (Pelco product #16023). A second lead wire was attached the same way to the other open conductor pad on the array chip. The chip was then allowed to dry for at least 4 hours at 120°C.

D. IR Thermographic Measurements

The test chamber comprised a 2.75" cube containing input and output valves for gas flow, a 1" MgF window, two thermocouple feedthroughs and two electrical feedthroughs. The electrical feedthroughs provided connections to the sample heater (Advanced Ceramics, Boralectric heater # HT-42) and the voltage/current measuring unit (Keithley Instruments model #236). The gas flows were regulated using a multi-gas controller (MKS model #647B). The sample heater was controlled using a unit from Hampton Controls (70VAC/700W phase angle). The infrared camera (Inframetrics PM390) was focused on the front surface of the array chip using a 100 $\mu$m close-up lens during the measurements.

Before the measurements were made the sample was placed inside the test chamber on top of the sample heater. The female pins on the lead wires connected to the array chip were then connected to the electrical feedthrough connected to the voltage/current measuring unit. The chamber was closed and placed in the visual path of the IR camera. Gas (100 sccm $N_2$, 25 sccm $O_2$) was then allowed to flow into the chamber during heating of the sample. Next, the sample was heated (approximately 10°C/minute) to the desired temperature and equilibrated before the voltage/current measuring

unit was turned on and a voltage applied. The voltage was typically adjusted to allow a current flow of between 10-20 mA through the array.

IR thermographic images of the array of materials were taken 20 minutes after each change in the flows of the following gases: $N_2$, $O_2$, and gas mixtures as follows: 1%CO/99% $N_2$, 1% $NO_2$/99% $N_2$ and 1% $C_4H_{10}$/99%$N_2$. Unless otherwise noted, the content of all gas mixtures described below is stated in percent by volume. The temperatures of the materials in 2% $O_2$/98% $N_2$ were subtracted from their temperatures in the other gas mixtures to determine the temperature signals in the examples. ThermMonitor 95 Pro, version 1.61 (Thermoteknix Systems, Ltd.) was used to do the temperature subtractions. When exposed to a donor gas, n-type semiconducting materials will have a decrease in resistivity, increasing the current and therefore, will show an increase in temperature due to $I^2R$ heating. When exposed to an acceptor gas, n-type semiconducting materials will have an increase in resistivity, decreasing the current and therefore will show a decrease in temperature due to $I^2R$ heating. The opposite occurs with p-type semiconducting materials.

AC Impedance Samples and Measurements

A. Semiconducting Metal Oxide Paste Preparation

Approximately 2-3 grams of the semiconducting metal oxide powder or the mixture of a semiconducting metal oxide with a suitable glass frit (DuPont *i*Technologies product #F2889 or F3876) or the mixture of the semiconducting metal oxide with other inorganic compounds was weighed out with an amount of a suitable medium (DuPont *i*Technologies product #M2619) sufficient to provide approximately 40-70 weight % solids. These materials were then transferred to a muller (Hoover automatic muller, model #M5) where they were mixed together using a spatula until no dry powder was left. If needed, a suitable surfactant, such as DuPont *i*Technologies product #R0546, was added to reduce the